MINERALOGY AND PETROLOGY OF "NEW" LUNAR METEORITE DHOFAR 025. J. Cahill[1], B. A. Cohen[1], L. A. Taylor[1] and M. A. Nazarov[2]; [1]Planetary Geosciences Institute, University of Tennessee, Knoxville, TN 37996 (jcahill@utkux.utk.edu), [2]Vernadsky Institute of Geochemistry, Moscow 117975, Russia.

Introduction: Lunar meteorite Dhofar 025 (Dh25) was found in January, 2000, in the desert near Dhofar, Oman. It is classified as an anorthositic regolith breccia [1]. Oxygen isotopes confirm its lunar origin [2] though noble gas abundances show that it is unpaired with the lunar meteorite Dhofar 026 found nearby [3]. Two contrasting clast types, primary-igneous rocks and impact-melt fragments, are accompanied by mineral clasts and set within a dark, melt-rich matrix. The majority of the bimineralic clasts, including the primary rocks, plot within the "gap" between the FAN and HMS fields on a graph of Mg# versus An. These unusual clast chemistries are indicative of a FAN–rich locale for the origin of this lunar rock, with a limited content of HMS constituents, typical of the lunar farside. The presence of terrestrially formed akaganéite (β-FeOOH) rimming FeNi grains is indicative of precursor lawrencite ($FeCl_2$), also occurring in numerous Apollo 16 samples [4]. This is possible evidence for impact-induced chlorine metasomatism in lunar highlands, causing the initial formation of lawrencite.

Petrographic Description: Dh25 is an anorthositic regolith breccia with a glass- and melt-rich matrix containing mineral fragments, primary igneous rocks, and impact-melt clasts. Schlieren textures and vesicles are abundant. A fusion crust is absent, and terrestrial alteration products are present at the meteorite edges and in penetrating cracks. No clasts with mare compositions or granulitic textures were observed.

In the two thin sections examined, a limited number (4) of clasts are true lithic fragments. These consist of single-crystal plagioclase poikilitically enclosing pyroxene and/or olivine (Fig. 1). Compositionally, these rocks resemble anorthosites and troctolites. Most clasts (30 studied) are impact-melt rocks. They have microporphrytic textures that include plagioclase crystals within a crystalline mafic-mineral + feldspar matrix. Relic rocks and minerals are often included within melt clasts, where they are partially resorbed and often embayed by the surrounding melt (Fig. 1).

Mineral Chemistry: *Melt clasts.* Though the mafic minerals in the melt matrix are too small to analyze (<3 μm), the porphyritic feldspar in most clasts is extremely anorthite-rich (An_{96-98}), with a lower limit of An_{94}. Relic rock fragments have plagioclase compositions identical to that of the melt matrix. Relic rocks and minerals within the melt matrix are olivine and/or pyroxene. Pyroxene compositions within the same clast may be different. Mafic-mineral compositions are shown in Fig. 2.

Most clasts (23) include relic mafic minerals with similar Mg# within the clast, indicating that the relic minerals are derived from a similar source. The Mg# of these relic minerals ranges smoothly from 65<Mg#<80. In the clasts where it occurs, olivine is homogeneous, with the exception of one rimmed oli-vine (rim Fo_{75}, core Fo_{81}). Several (5) clasts have mafic minerals which differ in Mg# within the same clast, indicating different sources for these relics prior to their incorporation in the single melt clast. However, the individual olivine and pyroxene grains have Mg#'s within the range defined above.

Rocks. True lithic clasts of anorthosite/troctolite rocks contain unzoned olivines. One troctolitic rock has Mg-rich olivines (Fo_{88-89}) and a single pyroxene grain containing both augite and pigeonite, both with Mg#=89. The plagioclase in this atypical troctolitic fragment has the lowest CaO content (An_{91}) of all observed clasts, indicating a high-magnesium suite (HMS) member. Anorthositic rocks have more Fe-rich olivines ranging from Fo_{69-80}, but lack pyroxenes. Plagioclase is consistently An_{96-98}.

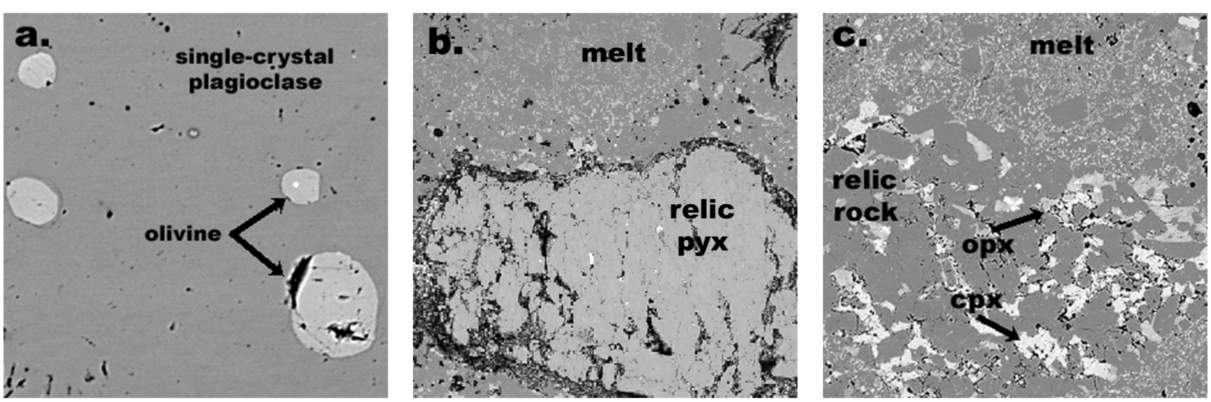

Figure 1. BSE images of Dh25 clasts: a) primary troctolite; b) relic mineral in melt; c) relic rock in melt.

Mineral Fragments. The largest mineral fragments are 200-600 μm. Plagioclase is An_{95-98}. Pyroxenes are single-mineral orthopyroxene (Mg#~75), pigeonite (Mg#=65-69), or augite fragments (Mg#=66- 80). Bimineralic augite and orthopyroxene fragments also exist (Mg#=79 and 75, resp.).

Matrix. Accessory minerals in the breccia matrix include spinel (Mg#=67-69) and ilmenite (MgO=6-9%). Other accessory minerals include FeNi metal (Ni=6-30%, Co=0.4-1.5%), troilite, and silica. The FeNi grains typically have β-FeOOH (akaganéite) rimming them, similar to many Apollo 16 highland rocks [4]. Akaganéite probably formed by terrestrial oxyhydration of $FeCl_2$ (lawrencite) that was present in the lunar meteorite as it left the Moon. Upon entry into the terrestrial environment, the formation of the akaganeite proceeded, similar to the Apollo 16 scenario. This reaction also released HCl that permeated the meteorite specifically altering the olivine with brownish staining. Other terrestrial alteration products include celestite, gypsum, calcite, and apatite.

The FAN-HMS Gap: The usual manner for depicting highland rock compositions is on an Mg# versus An plot. The rock and impact-melt clasts exhibit diverse compositional signatures on such a graph (Fig. 3). The single troctolitic rock is decidedly HMS derived. However, the anorthositic rocks have signatures between the HMS and FAN source regions, within the "gap" where granulites commonly plot. The melt clasts are plotted using the Mg# of relic mafic minerals and the An content of a relic feldspar or the melt matrix itself, with an An content similar to the observed relic rock plagioclase An contents. Like the rock clasts, the melt clasts also have intermediate signatures, smoothly ranging between the FAN and the HMS suite.

In all prior lunar rock studies, the only samples plotting in the HMS-FAN gap have been granulites or granulitic impactites [5]. *Though the majority of Dh25 clasts plot in the granulite field, they do not have metamorphic textures typical of granulites.*

The Mg# versus An plot only represents the composition of the mafic and plagioclase minerals in the clasts, not the modal mineralogy or bulk composition of the clast. It may be possible to have two rocks with the same chemical signature on this plot but different modal mineralogies and whole-rock chemistry. One rock could have fractionated from an HMS source and another from a FAN source but both might still end up with similar chemical signatures.

We propose that "new" rock types occur as clasts in Dh25, and they are actually extensions of the traditional HMS and/or FAN suites. Furthermore, these two fields may actually connect or overlap as seen in terrestrial examples like the Stillwater Complex [6].

Conclusions: The rock clasts, impact-melt clasts, and mineral fragments in Dh25 have been derived from a largely FAN-rich terrain, with few fractionated HMS constituents. Such a locale is certainly not common to the Apollo- and Luna-sampled regions. In fact, *this lunar meteorite with its "new array" of primary anorthosites in the FAN-HMS gap could well represent rocks from the farside of the Moon*, where the highlands are distinctly more FAN rich.

References: [1] Nazarov et al. (2000) *MAPS 35*, A202. [2] Shukolyukov (2001) this volume. [3] Taylor et al. (2001) this volume. [4] Taylor et al. (1973) *Lunar Sci. Conf. 4th*, 829-839. [5] Cushing et al. (1999) *MAPS 34*, 185-195. [6] Raedeke and McCallum (1980) in *Lunar Highlands Crust*, 133-153.

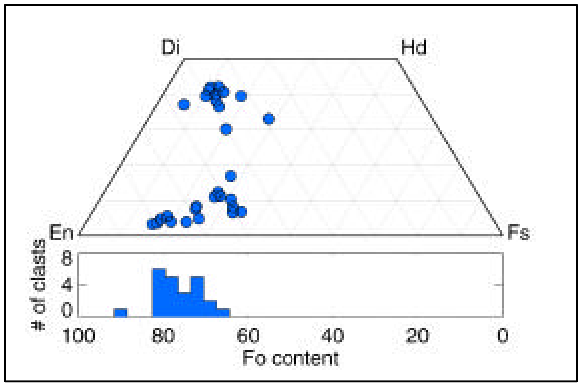

Figure 2: Pyroxene and olivine compositions in Dh25 (including rocks, melts, and mineral fragments).

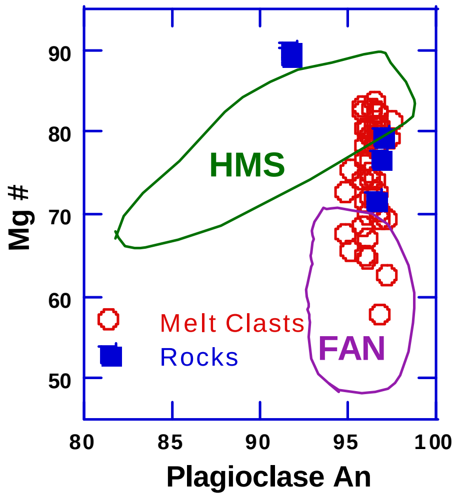

Figure 3. Mg# vs. An content of Dh25 clasts. Most clasts plot in the HMS-FAN "gap"